LISBOA
SCHOOL OF
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MASTER OF SCIENCE IN

FINANCE

MASTERS FINAL WORK

DISSERTATION

THE IMPACT OF BOARD GENDER DIVERSITY ON R&D INVESTMENTS

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ABSTRACT

Firms worldwide must discuss and address the under-representation of women in senior positions. Growing regulatory pressure emerges. The European Commission's proposal of a gender quota on the board of directors has been recently accepted through the European Parliament. The proposal is on its way through the legislative process. According to that proposal large firms must meet the demands for gender equality in the boardroom by 2020. The discussion in Europe will also trigger debates in non-European regions sooner or later. In this context it is essential to ascertain how gender quota regulations will affect company's performances and the general economic evolution. Economic growth is driven by innovation, research and development of new technologies. We extend the existing research by investigating the relationship between corporate board composition in terms of gender diversity and its investments in research and development. Research and Development activities have the potential to stimulate economic development. Does gender-diversity in the boardroom matter for a firm's research and development investments? We have a large sample of companies across nations. This enables us to compare different geographic regions, which is also an extension of existing empirical work. We find mixed results for the influence of gender diversity on research and development investments and find large differences in the world.

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TABLE OF CONTENTS

I. List of Abbreviations

EBITDA	Earnings before Interest, Taxes, Depreciation and Amortization
EU	European Union
FE	Fixed Effect(s)
IAS	International Accounting Standard
IFRS	International Financial Reporting Standards
IPO	Initial Public Offer
GIC	Global Industry Classification
GLS	General Least Squares
MCAR	Missing Completely at Random
OLS	Ordinary Least Squares
R&D	Research and Development
RE	Random Effect(s)
ROA	Return on Assets
ROE	Return on Equity
ROI	Return on Investments
S.D.	Standard Deviation
U.S.	United States
USD	United States Dollar
US GAAP	United States Generally Accepted Accounting Principles
WOCB	Women on Corporate Board of Directors

II. List of Tables

III. List of Figures

1 INTRODUCTION

The board composition of a company is currently one of the most discussed issues in Corporate Governance. This is evident from both: the vast number of academic research in this field, as well as the political discussions (EU implementation). Gregory (2012) mentions "board composition and diversity" as one of the twelve key issues in Corporate Governance. The effect of board diversity on corporate success has been studied extensively in the past years. Gender diversity is likely to turn out as the most important category of board diversity when studying board composition. Various quota systems appeared in legislation recently to promote gender diversity in board composition. First in Norway in 2005, and then in other European countries like France, Spain, Italy, Netherlands or Germany. Politicians, researchers, shareholders and businessmen are interested in the effects of such quotas. Do firms perform better if their board is (more) diverse? This question is addressed in numerous studies, with very ambitious results.

The present thesis aims to examine the relationship between a firm's gender diversity in the boardroom and its expenses in research and development (R&D). Innovation helps firms to survive, grow, become more efficient and ultimately more profitable than non-investing firms (Atalay et al., 2013). R&D activities contribute to the long-term growth of the firm. R&D activities explore new ways of conducting economic activity and develop new products and strategies. Those activities enhance the competitiveness and the ability to increase the profits, because they are likely leading to a decrease of production costs and an increase in the added value of the firm (Mansfield, 1996).

The causal relationship between board composition and the impact on various corporate issues is drawn up from a number of different theories related to economic and sociological fields. Those theories, namely the agency theory, the human resource theory and the resource dependency theory are briefly introduced and set into the context in

chapter 2.2. An important issue in this context, known as tokenism, will be explained in 2.3. A survey of the most important studies on board diversity affecting R&D and firm performance is the subject of chapter 2.4. The Theoretical considerations and the cognition from the literature review are the basis for our hypotheses. The empirical investigation in chapter 3 is commonly structured and completed with the regression results. Finally conclusion is derived and recommendations for further research are given.

2 THEORETICAL CONSIDERATIONS AND LITERATURE REVIEW

2.1 Definition of Gender Diversity and R&D

The understanding of what both gender diversity and R&D mean in the context of this thesis is crucial. Diversity is not commonly defined, but refers mostly to the heterogeneity of the individuals in one group. If a group is called diverse, it means that this group consists of many different people with different characteristics such as background, education, tenure, race or sex. Blau (1977, p.276) found a quantitative measure for diversity. According to him diversity is ”the great number of different statuses among which a population is distributed“. This indicator is called Blau index and measures the variation in categorial data.[1] This index is very useful when determining diversity with various categories such as race, education, age etc. and is used by many researchers. This thesis solely investigates the diversity in one category - on gender diversity - and hence diversity is measured here by the absolute number of women on the board of directors (WOCB). We don’t use an index, because women are a minority in all companies in the sample set.

R&D activities exist all over the world, but there are some characteristics that distinguish them from other scientific activities (Frascati manual, 2002). The Frascati manual defines R&D as „creative

[1] Blau Index = $1 - \Sigma (p_i)^2$, where p_i is the proportion of group members in each of the i number of categories

work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications.“ When R&D is conducted by a company, the monetary effects must be disclosed, if not immaterial.

The International Accounting Standard (IAS) defines research as an “original and planned investigation undertaken with the prospect of gaining new scientific or technical knowledge and understanding” (IAS 38). The standard also defines development as “the application of research findings or other knowledge to a plan or design for the production of new or substantially improved materials, devices, products, processes, systems or services before the start of commercial production or use’’ (IAS 38, §8).

From these two definitions, R&D activities can be understood as all actions that a firm takes with the purpose to develop new or enhance existing business opportunities. The problem with this definition is that a firm sometimes might have also R&D activities that do not produce costs as defined above. One example is organizational innovation (Miller & Triana, 2009). In line with previous research, we will approximate R&D activities by the expenses in R&D published in the income statement (Pantagakis et al., 2012).

Up to the present, there is a gap in the empirical work between the relationship of gender diversity and R&D activities. Therefore, we will also explore the relationship between R&D and firm performance as well as Gender diversity and firm performance.

2.2 Theoretical Framework

The influence of board diversity on various corporate issues is not derived from only single theory. On the contrary, various perspectives on the firm result in the application of several theories. The most relevant theories will be explained in the next section. As the review of existing empirical works will illustrate, there is not yet a consensus reached, about the impact of board diversity on the firm.

2.2.1 Agency Theory

Most of the advantages and benefits that board gender diversity yields for firm performance are tied to agency theory. Jensen & Meckling (1976) show that, through the separation of ownership and control a conflict of interest might lead to non-optimal management decisions. Directors that do not have a current or potential business relationship to the firm are more likely to make decisions solely in the interest of the shareholders (Becht et al., 2003). As reviewed by Ferreira (2010) a higher degree of independent directors leads to better monitoring. On the other hand, directors who have a current relationship to the firm (e.g. chief executives) are more likely to reveal firm-specific information to outside directors if they expect this information to improve the quality of advice provided by directors (Ferreira, 2010). In this way, the advisory function is can be improved. The connection to gender diversity is made by the argument that women are less likely to belong to the "old boys club" (Staubo, 2010). Hence, more gender diverse boards lead to better control mechanisms. Improved control mechanisms imply a better performance (Carter et al., 2010). Counter arguments assert that in some circumstances, board diversity might be also useless: The voice of a minority board member may not be heard by the majority (Westphal & Milton, 2000). So the "benefit" that women might bring to the board here is simply the possible independence. This is a very weak argument and actually discriminating men, since it assumes men being less independent than women. It is not a woman that improves something, it is the enhanced diversity a woman may bring to a homogeneous board. Hence if a board is already diverse or has good control mechanisms established, a benefit of additional diversity cannot be expected. The agency framework considers managers as risk averse (Fama, 1980). R&D spending is risky because of the uncertainty of future outcomes (Zona et al., 2013). Therefore, executives might invest less than optimally expected by shareholders who can diversify their risk among other companies (Zona et al., 2013).

2.2.2 Resource Dependence Theory

While the agency theory emphasizes the director's function of controlling, the resource dependence theory, developed by Pfeffer & Salancik (1978), underlines the obligation of directors to acquire sufficient resources for the operations and to assure continuity of the organization. Critical resources are, for instance, all connections to key outsiders, advice and counsel. The choice of directors should maximize the access to critical resources (Dunn, 2012). Hillman et al. (2000) suggest that different types of directors will provide different beneficial resources to the firm. As a result, a more diverse board will provide more valuable resources, which should produce better firm performance and innovation.

2.2.3 Human Capital Theory

Individual's investments in education and experiences enlarge intellectual, creative and productive capabilities (Becker, 1964). Those capabilities are called personal human capital. Candidates seeking for boardroom appointments have generally acquired substantial human capital over a number of years (Terjesen et al., 2009). Following this theory, the argument, why women influence firm performance positively is quite evident: ignoring one group for management or boardroom position, means simply ignoring the resources that this group provides. Hence, a choice for one boardroom member cannot be optimal, when ignoring one pool of talents. This argument implicates the assumption that there is a substantial mass of women having, at least, equal human capital similar to men. This is a different research field and as such, not part of this thesis. Here, we take the view, that that a substantial mass of females with equivalent qualification as men exists, since the access to education is equal for both gender.

2.3 Critical Mass and Tokenism

Another issue that received little attention in the previous studies is the problem of tokenism. Tokenism is a situation when one individual (here it is a woman) is dominated by the others (here the men), and has no

substantial influence to the decisions. The rationale for appointing tokens to the board can be to meet legislative requirements or signal good governance. In fact, most companies that have women on their board have just a single woman or just two of them (Torchia et al., 2011). Are those women likely to have substantial influence to the corporation? Kramer et al. (2006) indicate that a critical mass is needed to allow a board to take advantage of gender diversity. Torchia et al. (2011) explored whether the number of women plays an important role and tried to find the "critical mass" that makes it possible to enhance the level of firm innovation. They employed a study with 317 Norwegian firms where women were the minority in the boardroom. The dependent variable is innovation. This variable had been measured by surveys sent to board members in the year 2005. They introduced three dummy variables: one woman, two women, more than two women and controlled for firm size and industry, as these factors are known to influence innovation. Their findings indicate, that a number of three women has to be reached, to enable women contributing significantly to firms innovation. Only one or two women on the board have no significant influence and hence are considered to be tokens.

2.4 Review of Related Literature

Board diversity has been associated with positive effects to creativity, innovation or new ideas (Galia & Zenou, 2012). Surprisingly, only few studies investigated this effect empirically (Alsos et al., 2013).

Studies that investigate the effect of (gender) diversity on innovation such as Turner (2009) and Østergaard (2011) do not look at the board of director's level. The studies on board diversity in the context of gender focus more on firm performance but not innovation or R&D activities, therefore, we will also explore the empirical work on the link between R&D and firm performance. However, some studies include R&D activities casually when looking at board gender diversity and firm performance.

2.4.1 Gender Diversity and R&D

The effect of gender diversity in decision making groups received mixed results in the literature. Diverse groups might enhance creativity and innovation because the individuals bring different perspectives, knowledge and experiences into the decision making process (Gul et al., 2011). On the other hand, diversity could hamper if the task is simple and/or structured as Kravitz (2003) notes. Board decisions are usually neither simple nor structured. Consequently, we do not expect a negative influence of board diversity to the board decisions.

Galia and Zenou (2012) investigated the effect of board gender diversity on innovation with a sample of 176 french firms. Their sample had been collected from surveys and cover the period 2006 – 2008. They identified four types of innovation (product, process, organizational and marketing) and studied the effect of board gender diversity in each of the types. They found a negative relationship between WOCB and product innovation, but a positive for WOCB and marketing innovation and explain this gap by stating that „women on boards bring more impact in terms of understanding and targeting consumers' needs and markets, than on introduction itself of new products or new services“ (Galia & Zenou, 2012).

Some US chief executives recognized, that a lack of diversity on a board can contribute to lack of critical thinking and innovation (Mattis, 2000). Regarding the strategic decision of carrying out R&D activities we expect an influence of WOCB to R&D:

In line with the Agency theory, the influence on R&D is expected to be negative, as the controlling function with its postoperative character may see R&D as a negative influence for current performance, or critically find that the R&D activities are not likely to lead to the desired output. If a more gender diverse board is assumed to increase control mechanisms (agency theory), WOCB may affect R&D in four ways[2]. A start or increase of R&D activities is viewed positively. From the

[2] start, stop, increase or decrease.

resource dependence theory and the human resource theory, we can expect a positive influence on R&D. We test this statement through the hypotheses in chapter 2.6

2.4.2 R&D and Firm Performance

R&D activities ideally result in new business opportunities or cost reduction through innovation. Firm performance is usually measured by return variables, or market orientated measures, such as the ratio between market capitalization and book value of total assets. As R&D activities should improve future business opportunities, a causal relationship between R&D and firm performance appears plausible. Various studies explored the effects of R&D activities on firm performance and future returns. Ali et al. (2012) find that firms that increase research and development expenses, experience future abnormal returns. They explain this positive effect by a possible undervaluation in the market when R&D occurs and the correction appears when the benefits of R&D activities become visible. They argue that shareholders must focus more on this phenomenon of undervaluation. Cuervo-Cazurra and Annique Un (2010) link the firms decision to perform R&D or not to the real options theory (see Brach, 2003; Damodaran, 2012; Fisher, 1930). Briefly, the option is exercised if the expected capital value surmounts the expected costs. Conditional to that, the option of investing in research and development must be available to the firm and therefore some innovative ideas or relation to other firms must be established. Chan et al. (2010) and Chambers et al. (2002) also find a positive associations between future stock returns and current R&D intensity.

If such causal relationship between R&D and firm performance exists, as well as a causal relationship between Gender diversity and firm performance, a relationship between gender diversity and R&D expenses appears most likely. Because of their strategic character, R&D decisions are considered being directly linked to decisions made by the board of directors. Miller & Triana (2009) indicate such relationship by using innovation as a mediator between gender diversity

and firm performance.

2.4.3 Board Gender Diversity and Firm Performance

There is no consensus reached about the impact of gender diversity on firm performance.

Erhardt et al. (2003) investigate a sample of 112 large U.S. firms. They find a positive relationship between firm performance, measured in Return on Investment (ROI) and Return on Assets (ROA), and gender diversity in the board room. Similarly, Campbell & Mínguez-Vera (2008), for the case of 68 Spanish companies, find a positive relationship between a firm's financial performance and board gender diversity. They use Tobin's Q[3] as a measure for the firm's financial performance. They do not control for industry sector, although mentioning the findings of Brammer et al. (2007) who found that the concentration of women in a corporate board is depending (also) on the industry sector. There is a significant higher percentage of women in sectors that operate near the end consumer, such as retailing, banking, media and utilities.

Shrader et al. (1997) inspect a sample of 200 large firms from the United States. They test the effect of the number of women at different levels: management, top management and board. The effect of percentage of women on board in 1992 on performance measures, taken one year later such as Return on Equity (ROE), ROI, ROA are either not significant or negativly significant in their sample.

Adams & Ferreira (2009) have done the most robust analysis to board gender diversity because they were testing various models. Also, their sample and panel period is larger, consisting of 1939 listed US firms with data for the years 1996 - 2003. The relationship between females on the board and the firm's performance, assessed by Tobin's Q and ROA is positive and significant using ordinary least squares (OLS) and taking industry dummies into account, but turns in to negative when considering firm fixed effects. For firms with a strong governance they

[3] ratio of the market value and the book value of a company.

found a negative relation.

Miller & Triana (2009) use a sample of 326 US firms and do not find any relationship between gender diversity in the boardroom and firm's financial performance. They use innovation as a mediator.
Another study that does not find a link is Carter et al. (2010). They use a panel data set of 641 firms and using time and firm level fixed effects as well as robust standard errors, they do not find a relationship between firm performance and board gender diversity.

2.5 Causal Relationship between Board Diversity and Firm Innovation

The board of directors is a crucial factor that supports all the innovation activities and influences the level of firm innovation (Zahra & Garvis, 2000). The heterogeneity of the top management team promotes innovation in the firm (Torchia et al., 2011; Carter et al., 2010). As Torchia et al. (2011) and Alsos et al. (2013) highlight, only a few studies investigated the effect of such patterns of board diversity, such as gender or age, on innovation.

2.6 Development of Hypotheses

The rationale for a causal relationship between board diversity and R&D activities is drawn up from different theories that have been explained in chapter 2.2. Regarding the strategic decision of carrying out R&D activities we can also expect an influence of WOCB on R&D. If we argue with the Agency theory, the influence on R&D is more expected to be negative, as the controlling function with its postoperative character may see R&D as a negative influence for current performance, or critically find that the R&D activities are not likely to lead to the desired output. If a more gender diverse board is assumed to increase control mechanisms (agency theory), WOCB may affect R&D in three ways[4]. From the resource dependence theory and the

human resource theory, we can expect a positive influence on R&D. We test these statements with the following hypotheses.

Hypothesis 1: The proportion of WOCB has a positive effect on R&D investments.

The studies, that were introduced in chapter 2.4.3 indicate, that the effect of Board gender diversity might be different across nations. In Europe quota systems are on the legislative process. Therefore, we want to test this proposition with

Hypothesis 2: The effect of WOCB on R&D investments differs by the geographic origin of the company.

The assessment of the geographic origin is explained later.

The phenomena of tokenism had been assessed in chapter 2.3. To evidence the existence of a “critical mass” we formulate

Hypothesis 3: The number of women in the boardroom has no effect on R&D investments if there are less than 3 women in the board room.

The hypotheses are tested and validated in the next chapter. The next chapter provides an empirical analysis in order to answer the following question: Is there an influence of WOCB to R&D ?. This is the research question.

3 EMPIRICAL EXPLORATION

3.1 Data Collection and Sample Description

Data was collected from the Bloomberg database, the largest database available to us. It collects all financial information a company legally must disclose. Additionally, it collects company data in various fields, such as governance or management histories. Unfortunately this database suffers from some shortcomings on complete datasets resulting in missing values. However, we were able to gather a large, representative sample. To consider results being representative, the sample must be large enough and drawn randomly from the underlying population (Auer & Rottmann, 2012).

Our sample contains companies being active from 2008 until 2012 and having available data on its board size. As the board size is modest to determine, missing values are assumed to be missing completely at random and therefore this sample is a reverse random sample (Auer & Rottmann, 2012).
After cleaning the sample from missing data, we have balanced panel data available for 2,220 companies, resulting in 11,100 firm years.

3.1.1 Dependent Variable

The R&D activities are a proxy for a firm's (future) innovation and they are essential for the long-term success of a corporation (Flamm, 1990). We consider unstandardized R&D expenses as a good proxy for a firm's investment in its own future although there are also nonmonetary types of innovation, such as organizational, process or marketing innovation.

In order to compare different countries worldwide, the amounts are collected in million USD from the database. One feature of the Bloomberg database is that it automatically converts monetary data with the historical exchange rates, producing comparable data.

3.1.2 Independent Variables

a) Number of WOCB

We use the number of WOCB instead of proportion as an explanatory variable, because we want to compare the results on the different hypotheses, and the critical mass hypothesis explicitly demands for the number of WOCB. We introduce one lag to allow decisions of the board become visible.

b) Board Size

Following Erhardt et al. (2003) we use board size as a control variable and introduce also one time lag to allow board decisions becoming visible.

c) Firm Size

The firm size has an influence on R&D investment. Larger firms have the necessary financial and technical capabilities. They can spread the risk of failure through economies of scope and benefit from some more size-depending features (Damanpour, 2010, p.998).

Firm size is approximated by the natural logarithm of total assets (Finkelstein & Boyd, 1998).

d) Firm Age

Firm age is defined as the year of incorporation, not the years in business. This is important to remember at the interpretation. For 44 firms, the year of incorporation is later than 2008. Since these firms report data on all years, and often have an older date of initial public offer (IPO), these are firms that either merged or changed their legal form.

e) Industry Sector

As Figure 1 in the Appendix shows, R&D expenditures vary across industry sectors. We follow the procedure of Adams and Ferreira (2009) to control for industry effects that is, introducing dummy variables for each industry. We use the Global Classification Standard (GIC) as an identifyer.

f) Continent

To account for regional differences, we also use the continent where a company is installed. This is derived from the reported country of domicile. It is not necessary the country where a company operates, but usually this should be the same country where the board sits in.

g) Control Variables

The accounting figure “Earnings before Interest, Taxes, Depreciation and Amortization” (EBITDA) and performance measure Tobin's Q are used as a control variables. There might be an effect since the expenses on R&D activities might be seen as a cost by the market and hence leading to a decrease in market value of the firm. Also, R&D

expenses can be only activated under restrictive conditions[5] and hence it is difficult to increase the book value by the valuable R&D activities. Other performance and return variables are not expected to influence current or future R&D expenses. It is more the other way around, that R&D expenses or activities should affect those variables in the future. This is the main purpose of R&D activities. On the other hand, it might be plausible that more profitable firms may raise more sufficient funds for research and development. This relation, even though interesting, is out of the scope of this thesis. Accordingly, the model is restricted to the mentioned variables.

An overview of all used variables with their characteristics can be found in Table IX in the Appendix.

3.1.3 Discussion of Missing Data

Ignoring or discarding companies with missing data could bias the sample and make results useless (Baltagi, 2008).

Frees (2004, p.266) discusses three methods how to deal with partially missing data:

i) Use unbalanced estimation techniques.
ii) Utilize only subjects with complete set of observations, discard incomplete subjects.
iii) Impute values for missing observations.

Since the sample only includes five years and we use lagged independent variables, the first method seem not to be appropriate. The third method is also not recommendable in this case, because we have only five years of observations per subject, and the estimation error would be too high. The second option fits best to the nature of data, but depends heavily on the MCAR assumption. Missing data on R&D were substituted by zero if and only if the previous and the following values were also zero, or if all subsequent or previous values equalled zero. This can be justified by the long term nature of R&D activities. Other missing values are assumed to miss completely at random because we

[5] See for example IAS 18

suppose that there was an error in disclosure or data collection of Bloomberg. Therefore, those companies were discarded from the sample.

The sample contained only three companies with missing data on number and percentage of WOCB. This number is too small to bias the results.

Thus we have a balanced panel of 2,220 firms with 5 year observations, consequently 11,100 firm years.

3.1.4 Descriptive Statistics and Correlation

Table I shows the female representation of WOCB in the world. 59% of all companies in the sample had (on average) no woman in the board of directors. This table

TABLE I.FEMALE REPRESENTATION ON CORPORATE BOARDS (WORLDWIDE)

2220 companies	2008	2009	2010	2011	2012	Average	Proportion
no woman	1381	1349	1322	1268	1232	1310.4	59.03 %
one woman	497	507	520	526	494	508.8	22.92 %
two women	232	246	261	284	319	268.4	12.09 %
more than two women	110	118	117	142	175	132.4	5.96 %

The next tables show a summary of variables and the correlation matrix.

TABLE II. DESCRIPTIVE STATISTICS

	Variable name[6]	Mean	S.D.	Min	Max
1	RD	219.772	832.068	0	11,381.284
2	No. WOCB	0.672	0.981	0	7
3	% WOCB	6.751	9.604	0	62.5
4	Board Size	9.541	3.258	2	33
5	EBITDA	1,323.089	4,363.480	0.025	78,669
6	Total Assets	291,631.588	1,234,551.409	1.044	5.25E+07
7	Tobin's Q	0.552	12.001	0	1,247.233
8	Year of Incorporation	1966.281	31.805	1836	2014

The descriptive statistics show that there is a large variation in the monetary variables (1, 5, 6). The standard deviation is much higher than the mean. This means, that many firms have zero R&D while others have very high R&D. However, the R&D expenses are lognormally distributed (see Figure 1 in the Appendix). This is also true for the total assets and Tobin's Q. We can conclude here, that the firms in the sample are very heterogeneous, which is not surprising as we have a sample across industries and continents. To account for this problem, we take the natural logarithm of each monetary variable.

TABLE III. CORRELATION TABLE

Variables	1	2	3	4	5	6	7	8
1 R&D	1							
2 No. WOCB	0.19***	1						
3 % WOCB	0.13***	0.95***	1					
4 Board Size	0.22***	0.25***	0.09***	1				
5 EBITDA	0.47***	0.26***	0.18***	0.25***	1			
6 Total Assets	0.4***	0.19***	0.11***	0.27*	0.52***	1		
7 Tobin's Q	0	-0.01	0	-0.03	-0.01	-0.01	1	
8 Year of Incorporation	-0.04***	0.14***	0.18***	-0.16***	0.02	-0.01	0.03***	1

* p<0.05, ** p<0.01, *** p<0.001

[6] Variables 1, 5 and 6 were measured in million USD.

All correlations among the independent variables are low, except of course for the number and percentage of WOCB. These two variables are not included at the same time in the regressions. If one of the independent variables is highly correlated with another independent variable the problem of multicollinearity occurs (Wooldridge, 2010). Multicollinearity in a regression means, that two or more variables influence the dependent variable in the same way, so we can't distinguish the individual effect of each variable on the dependant variable and we obtain biased coefficient estimations. In addition to that, the ceteris paribus assumption may not be applicable for very high correlated variables. The problem of multicollinearity is not apparent (evident) in this case.

3.2 Model Specifications

To answer the research question formulated in the beginning of this chapter, multiple linear regression models are applied. A Multiple linear regression is a regression model where the dependent variable is continuous, explained by several exogenous variables, and linear in the parameters (Baltagi, 2008).

Following the previous literature in this field, the coefficients of the model are estimated through the method of ordinary least square (OLS) regressions and then the advanced panel data methods fixed and random effects estimation are applied (Adams & Ferreira, 2009; Erhardt et al., 2003; Miller & Triana, 2009).

In this case, where cross-sectional time series data is available, the model for the regression can be specified as follows:

$$Y_{it} = \beta_0 + \beta_1 X_{it1} + \beta_2 X_{it2} + \ldots + \beta_k X_{itk} + a_i + u_{it} \quad (1)$$

Where

Y_t	ln of RD investments in t
X_{1t-1}	Number of WOCB in t-1
X_{2t-1}	Board Size in t-1

X_{3t-1}	Ln of Total Assets in t-1
X_{4t-1}	Ln of EBITDA in t-1
X_5	Firm age (year of Foundation)
X_6	Sector
X_7	Continent

The R&D expenditures are log transformed in order to account for their distribution (see the normal quantile plot, Figure 2 in the Appendix). For reasons of simplicity, all other monetary values are also log transformed. The random and fixed effects estimation methods are able to address unobservable heterogeneity. Unobservable heterogeneity is a situation where some special characteristics of a firm that are not observed have an influence on the dependent variable. This influence might be for example a firm's overall government policy or the chance of receiving subsidies for R&D. The first is likely to have also an influence on WOCB. The latter might not influence WOCB. Subsidies affect the return on invested capital but as they are paid upfront the independent lagged variable EBITDA is not expected to be influenced by the firm specific effect.

Assuming that the unobserved effect a_i is uncorrelated with all independent variables, equation (1) becomes a random effect model (Wooldridge, 2010, p.492), with

$$\text{Cov}\,(x_{itk}, a_i) = 0 \qquad (2)$$

In order to test whether the unobserved effect a_i is correlated a Hausman test is conducted (Hausman, 1978).

3.3 Empirical Results

First of all, we estimate the econometric model by the classical method OLS. Also, we used the GLS estimation to fit the FE, RE models. Such estimations aim to test the hypotheses formulated. Table IV summarizes the results. The GLS regressions are more suitable in this case because they correct estimated coefficients for the omitted variable bias and presence of autocorrelation relationship and heteroskedasticity in pooled time series data (Hoechle, 2007).

Alternatively to the Breusch-Pagan test we used the White test, which does not assume a specific form of heteroskedasticity (Wooldridge, 2010). The White test rejected the null hypothesis of constant variance (p-value=0.0000) which means, that we have heteroskedasticity and therefore, the OLS regressions do not provide the best linear unbiased estimators.

TABLE IV. RESULTS OF REGRESSIONS: R&D ON WOCB

Dependent Variables	Independent Variable: ln (R&D)			
	(OLS)	(AREG)	(FE)	(RE)
Number of $WOCB_{t-1}$	-0.0323	0.0529*	0.0529*	0.0630*
	(0.0244)	(0.0135)	(0.0141)	(0.0138)
Board $Size_{t-1}$	0.0234*	0.0052	0.0052	0.0236*
	(0.0064)	(0.0055)	(0.0056)	(0.0055)
ln (Total $Assets_{t-1}$)	0.1417*	0.0844*	0.0844*	0.177*
	(0.0119)	(0.0108)	(0.0119)	(0.0119)
ln ($EBITDA_{t-1}$)	0.6416*	0.0925*	0.0925*	0.1936*
	(0.0158)	(0.0106)	(0.0112)	(0.0137)
Year of Incorporation	-0.0064*	omitted	omitted	-0.0094*
	(0.0006)	(.)	(.)	(0.00145
Tobin's Q	0.0022*	-0.0001	-0.0001*	-0.0001**
	(0.0011)	(0.0001)	(0.0000)	(0.0000)
Continent Effects[7]	Yes	No	No	Yes
Sector effects	Yes	No	No	Yes
Constant	8.7895*	2.2328*	2.2328*	16.9266*
	(1.2577)	(0.1268)	(0.1371)	(2.9506)
Observations	6306	6306	6306	6306
R-squared	0.5899	0.9783	0.0364	
Adjusted R-squared	0.5886	0.9708	0.0356	

(Robust)[8] Standard errors in parentheses
* p<0.05, ** p<0.01, *** p<0.001

[7] Continent and Sector were included with dummy variables. For AREG and FE results, we did not include them because they don't change over time.
[8] For all regressions except OLS we used robust standard errors.

The first estimation in Table IV is a simple OLS and shows no significant relationship between WOCB and R&D. But the results are biased due to the fact that (other) firm specific effects are not taken into account. Both, the fixed effects and the random effects model show the same prefix and significance levels on the coefficients. But the coefficients from the random effects estimation are slightly higher than from the fixed-effects regression. The fixed effects model uses the variation within one panel, therefore, values, that keep constant over the time period are omitted. This is the case for the year of incorporation, continent and sector of one company. In the sample, those values did not change over time. The AREG and FE results do not differ in the coefficients, but in the level of errors and the reported R squared. R-square reports how much of the variability of the dependent variable can be explained by the independent variables (Wooldridge, 2010). The R-squared of the FE estimation has not much explanatory power because this type of regression uses the within variation (Cameron & Trivedi, 2009). Therefore, we also show the AREG results.

The random-effect model estimation assumes that the unobserved heterogeneity is not correlated with the independent variables. We conduct a Hausman test to validate which model is more suitable. The Hausman test for the basic model shows that the differences are systematic in the two regressions (Prob> Chi2 = 0.000). This means, that the assumption for the random-effect estimation is not valid, hence it is better to use the FE estimation methods. Accordingly, the further analysis is based on the fixed effects results. Continent and Industry effects are omitted because they do not vary over time. They are part of the firms fixed effects characteristics.

Table IV, column 3 and 4 show that there is positive relationship at the 5% significance level between the lagged number of females and the expenses on R&D. If one more woman is added to the board of directors, ceteris paribus the R&D expenses increases on average by 5.29% in the next year. Hence we can reject the alternative hypothesis that $\beta_1 \leq 0$ at 0.05 level of significance. This means Hypothesis 1 is

supported by our model. The other independent variables do also have significant influence on R&D. Larger and older firms are investing more in research and development. This is consistent with previous findings, e.g. Hillman et al. (2007). Larger firms may have sufficient funds for R&D. For Firm age, the year of incorporation (e. g. "founded in 1979") was used, in order to avoid increasing values by 1 each year. Hence, the negative coefficient means that younger firms invest, on average, less in R&D. Or, the other way around, older firms invest more. Older firms are likely to have experienced staff and knowledge to perform R&D activities.

Next, we want to see, whether the relationship between WOCB and R&D is different across continents. We still assume that the firm fixed effects remain the same as in the previous analysis and repeat the regression for each Continent.

TABLE V. RESULTS OF REGRESSIONS: R&D ON WOCB ACROSS CONTINENTS

Dependent variables	Independent Variable: ln (R&D)					
	Africa	Asia	Australia	Europe	North America	South America
No. of $WOCB_{t-1}$	0.0238	0.1877**	0.0299	0.0116	0.0343	-0.1869
	(0.2134)	(0.0642)	(0.0835)	(0.0188)	(0.0187)	(0.1506)
Board $Size_{t-1}$	0.1981	-0.0013	-0.0135	0.0127	0.0299*	0.1088
	(0.1158)	(0.0064)	(0.0518)	(0.0170)	(0.0138)	(0.1694)
ln(Total $Assets_{t-1}$)	-0.2157	0.1195***	-0.0423	0.0729*	0.0616***	0.3905
	(0.2501)	(0.0270)	(0.0706)	(0.0302)	(0.0134)	(0.2440)
ln($EBITDA_{t-1}$)	-0.0136	0.0993***	0.3019*	0.120***	0.0721***	-0.007
	(0.1601)	(0.0139)	(0.1233)	(0.0328)	(0.0200)	(0.1585)
Tobin's Q	1.2930	-0.0454**	-0.0157	0.0044	-0.0001***	-24.0635
	(1.6396)	(0.0154)	(0.0499)	(0.0180)	(0.0000)	(12.2747)
Constant	1.2050	1.4517***	1.291	2.7292***	3.0042***	-0.3587
	(2.7637)	(0.2802)	(0.9527)	(0.4034)	(0.1977)	(3.1747)
Observations	44	3329	107	952	1854	20
R^2	0.1423	0.0464	0.1183	0.0339	0.0440	0.3197
Adjusted R^2	0.0295	0.0449	0.0746	0.0288	0.0418	0.0767

Robust standard errors in parentheses
*p< 0.05, **p< 0.01, ***p< 0.001

Now, we see only in Asia there is a significant positive relationship of WOCB towards R&D. For the other continents, except South America the relationship is positive, but not significant anymore. While we have

assumed the fixed effects remain the same, the results indicate, that the fixed effects vary across continents. For Asia, the coefficient is more than three times higher than in the previous regression. A look to the female representation on corporate boards in Asia can shed some light to this puzzle (see also Table I):

TABLE VI. FEMALE REPRESENTATION ON CORPORATE BOARDS (ASIA)

1125 companies	2008	2009	2010	2011	2012	Average	Proportion
No woman	979	966	954	954	949	960.4	85%
One woman	107	120	124	119	126	119.2	11%
Two women	28	28	35	40	33	32.8	2%
More than two women	11	11	12	12	17	12.6	1%

About half of the companies in the sample are from Asia. And here the representation of WOCB is much lower than in the other regions. On average during the years 2008 to 2012 there were only 0.2 WOCB on the board of directors of Asian companies where the average board size was 9.75. On average 85% of the Asian companies had no women on their board, the average worldwide was 59% in this sample.

Compared to the Catalyst Report (2013) these figures are lower. The Catalyst reports only on US Fortune 500 Companies. Those are the largest or most powerful companies, which might be a good indicator, but cannot really being seen as representative for the economy. The worldwide sample that is used here takes also smaller companies (smaller than US Fortune 500, but still large) in account. This promises being more representative and giving more realistic picture.

According to the regression results in Table V if one more woman is added to the board of an Asian company and holding everything else constant, the R&D expenses on average would increase by 18% in the next year. But as the previous tables showed, the Number of WOCB in Asia is with 0.2 on average close to zero. Therefore we cannot conclude, that WOCB have such an effect on R&D expenses. Clearly, the results show that the effect of WOCB differs by continent

(Hypothesis 2), but do not support Hypothesis 1.

In section 2.3, we pointed out the theory of a critical mass. Some authors argue, that women do only have significant influence [..on performance..] if they are not simply used as a token. Three or more women are considered to be a number above tokenism (Kramer et al., 2006). Now, the fixed effects regression will be repeated on two different groups: the first has more than two WOCB; the second has less than three WOCB. As one company might change from one to the other group, we have an unbalanced panel now, but the procedure is the same:

TABLE VII. RESULTS OF REGRESSION: R&D ON WOCB GROUPED BY NO OF WOCB

Dependent Variables	Independent Variable: ln (R&D)	
	WOCB > 2	WOCB ≤ 2
Number of $WOCB_{t-1}$	0.0021	0.0655***
	(0.0188)	(0.0197)
Board $Size_{t-1}$	0.0376*	0.0043
	(0.0154)	(0.0059)
ln (Total $Assets_{t-1}$)	0.0471	0.0851***
	(0.0361)	(0.0123)
ln ($EBITDA_{t-1}$)	0.0353	0.0948***
	(0.0941)	(0.0112)
Tobin's Q	0.0219	-0.0002***
	(0.0425)	(0.0000)
Constant	3.9909***	2.1463***
	(0.8719)	(0.1400)
Observations	371	5935
R-squared	0.0385	0.0369
Adjusted R-squared	0.0253	0.0361

Robust standard errors in parentheses
*p< 0.05, **p< 0.01, ***p< 0.001

For the group of less than three women on corporate boards, the figures indicate a significant influence on R&D. If in this group, on average one woman is added to the board, the R&D expenses increase on average by 6.55%. Hypothesis 3 stated that there is no effect of

WOCB on R&D investments in this group. Hence Hypothesis 3 is not supported. This contradicts the findings of Miller & Triana (2009). A possible explanation is, that a board with three or more WOCB might be (gender) diverse enough and is not benefitting anymore from an additional woman. Indeed the argument that "too much diversity" is disadvantageous and it leads to a long decision processes, such explanation is discussed in the study of Adams & Ferreira (2009). In the case of R&D which is related to innovation, more diverse decision groups might lead to original ideas. In fact, an inverse u-shaped relationship appears plausible for diversity. Such a relationship would go beyond the possibilities of linear panel regressions and the framework of this thesis and is therefore not investigated further.

4 CONCLUSION

In this dissertation, we first depicted the theories that are usually referred when establishing a causal relationship between board gender diversity and firm performance. Then, we reviewed briefly the relevant literature in the field of board (gender) diversity and set it into the context to R&D activities. Subsequently, we formulated the hypotheses that WOCB positively influence R&D investments (H1), that the effect is different across regions worldwide (H2) and finally tested if a critical mass of WOCB for R&D investments exists (H3) and specified the model. We tested a sample of 2,220 worldwide firms for the period 2008 until 2012. Hypothesis 1 received mixed support. In the first regression analysis it was supported, but when investigating different regions worldwide, we had to revise this proposition since the effect was only driven from Asian firms, where only few WOCB exist. Women have different perspectives, experiences, ideas etc. than their male counterparts and if not appointed as tokens they will be heard. Thus, the enhanced gender diversity in the boardroom was expected to positively influence R&D activities. R&D activities include also non-monetary measures. On the monetary measures that were used here, the existence of a "Critical Mass" of WOCB that some scholars found

on firm performance could not be confirmed. The results here indicate, that a board with more than two women is diverse enough and R&D investments do not increase significantly after a third woman (or more) is added to the board. But the same might not be true for the non-monetary measures of innovation.

Board diversity remains an interesting field of research. We could not confirm any relation from the investigated sample, neither positive, nor negative of Board Gender Diversity towards R&D investments. We saw, that there are large differences around the world on the number of WOCB. But in all regions, WOCB remain a minority. From the firm perspective, an economic rational to improve (gender) diversity could not be found. Hence firms do not have an incentive to improve (gender) diversity. However, for reasons of fairness and equality improving, gender diversity must continue to be a focus of local and international governance. As such, structures must be established that enable (more) women to take key roles in economic sectors and political decisions to accelerate this process.

5 LIMITATIONS AND FUTURE RESEARCH

A broader analysis of board diversity and innovation is recommendable. More factors to measure diversity, such as age range, tenure, director's independency could be included to extend the econometric model used here and consequently point more determinants of innovation. These measures are hardly to determine for large samples, especially with worldwide companies. The data is not available for many countries, and if available possibly not comparable, since the definition of dependency might vary across countries. Even though, such data fields were available in Bloomberg, we had to assert that the quality and quantity of the data entries in those field simply did not comply with academic demand on integrity and accuracy. Those measures directly refer to personal biographies which are only occasionally complete in the database, in fact just for very well known people, but never for the whole board. We recommend including such measures in future

analysis. Also the determination of innovation can be improved, for instance with non-monetary measures. Such data must be possibly gathered through surveys as Torchia et al. (2011) did.

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V. APPENDIX

Figure 1 – R&D Expenses Over the Years 2008 – 2012 by Industry Sector

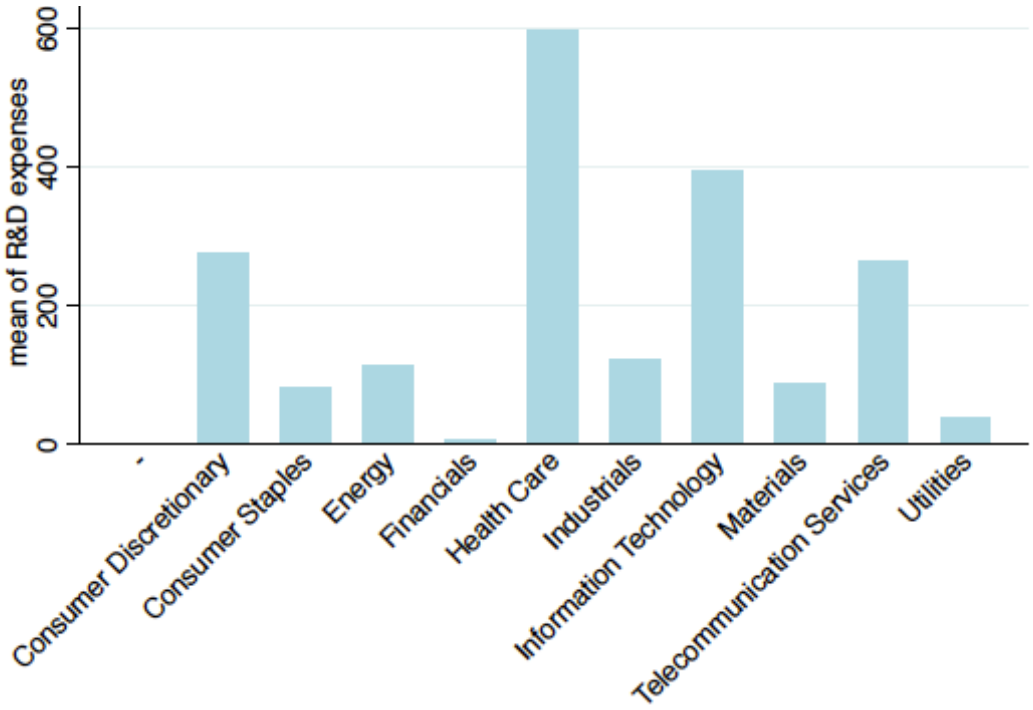

Figure 2 – Normal Quantile Plot ln(R&D)[9]

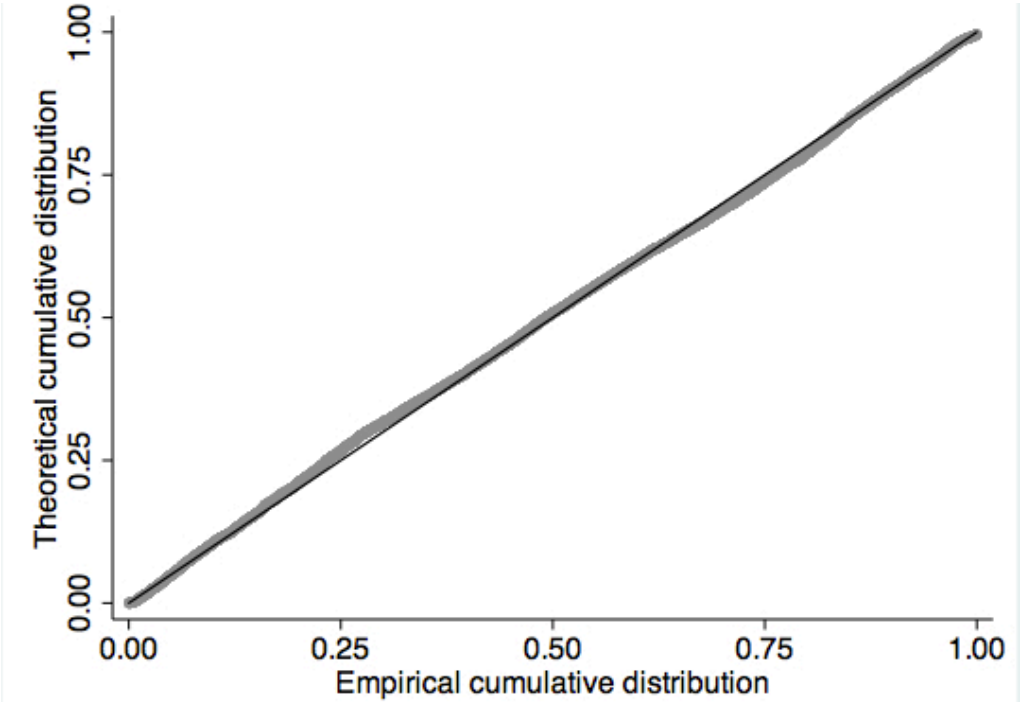

TABLE VIII. AVERAGE BOARD SIZE

	2008	2009	2010	2011	2012	Average
Africa	11.71	11.43	11.79	12.21	12.00	11.83
Asia	10.06	9.80	9.74	9.64	9.52	9.75
Australia	6.66	6.68	6.65	6.71	6.85	6.71
Europe	9.94	9.86	9.89	10.00	10.07	9.95
North America	9.41	9.47	9.44	9.44	9.50	9.45
South America	8.20	9.40	9.60	9.60	9.80	9.32
Average	9.68	9.56	9.52	9.49	9.46	9.54

[9] The plots for ln(Total Assets) and ln(EBITDA) lookalike. Therefore they are not shown here again.

TABLE IX. DESCRIPTION OF VARIABLES

Variable Name	Definition	Data Type	Dimension
unitid	id of company	numerical	
fy	Fiscalyear	numerical	
Board size	Number of boardmembers end of fiscalyear	discretenumerical	
nrfemalesonboard	number of WOCB end of fiscalyear	discretenumerical	
percfemalesonboard	percentage of females end of fiscalyear	quantitative	Percentage
rd	R&D expensesaccordingtocompanies Income Statement forfiscalyear, convertedwithcorrespondinghistoricalconversion rate if not stated in USD	quantitative	in million USD
ebitda	Earningsbefore Interest, Taxes, Depreciation, Armortization	quantitative	in million USD
totalequity	Total Equity aspublished in thebalancesheet	quantitative	in million USD
totalassets	Total Assetsaspublished in thebalancesheet	quantitative	in million USD
firstipo	date of firstpublicoffer	string	
country	Country of companiesDomicile	categorial	
Continent	continentwhere firm islocated (derivedfromcountry)	categorial	
Date_incorporation	date a company was established	string	
%Devel	dummycountry of firm isdevelopped /not developed	categorial	
Sector	GIC Sector	categorial	
Tobinsq	Tobin's Q	quantitative	Percentage